Section 7

7. PHYSICAL ENVIRONMENTAL, MINERAL RESOURCES AND CLIMATE

"Earth provides enough to satisfy every man's need, but not every man's greed." [10]

7-1 Topography

Fort Richardson lies between the Turnagain Arm and the Knik Arm of the Cook Inlet in a roughly triangular-shaped lowland. To the east, the Chugach Mountains rise abruptly to elevations over 5,000 feet. From an elevation of 1,000 feet at the base of the mountains, the land declines into the Anchorage plain to the coast. The Anchorage plain is a glacial moraine that extends from the mountain front westward and northwestward. Steep bluffs, broken only by principal streams such as Eagle River, characterize the edge of the plain as it drops sharply to the sea (CH2M Hill, 1994b). Figure 7-1 illustrates the topography of Fort Richardson.

The Anchorage plain as seen from the Chugach Mountains.

7-2 Geology

Geology of the Fort Richardson area was shaped by the formation of the Chugach Mountains in the late Paleozoic and Mesozoic Eras and the subsequent flow of sediments into lowlands during the Tertiary period (Gossweiler, 1984). The Chugach Mountains have a bedrock of metamorphic rocks of the McHugh complex composed of a mixture of metamorphose siltstone, lithic sandstone, arkose, and conglomerate sandstone (CH2M Hill, 1994b). The lowland's bedrock is composed of sedimentary rocks of conglomerate sandstone, mudstone, and coal. It is connected with metamorphic rocks of the mountains along the vertical Border Ranges Fault, that lies at the base of the Chugach Mountains (CH2M Hill, 1994b).

Rugged slopes of the Chugach Mountains.

Bedrock in lowlands rarely surfaces, because it is covered by thick deposits of unconsolidated material that accumulated during the Holocene Period, one million to ten thousand years ago (Gossweiler, 1984). These surface deposits begin at the moun-

[10] Mohandas K. Gandhi.

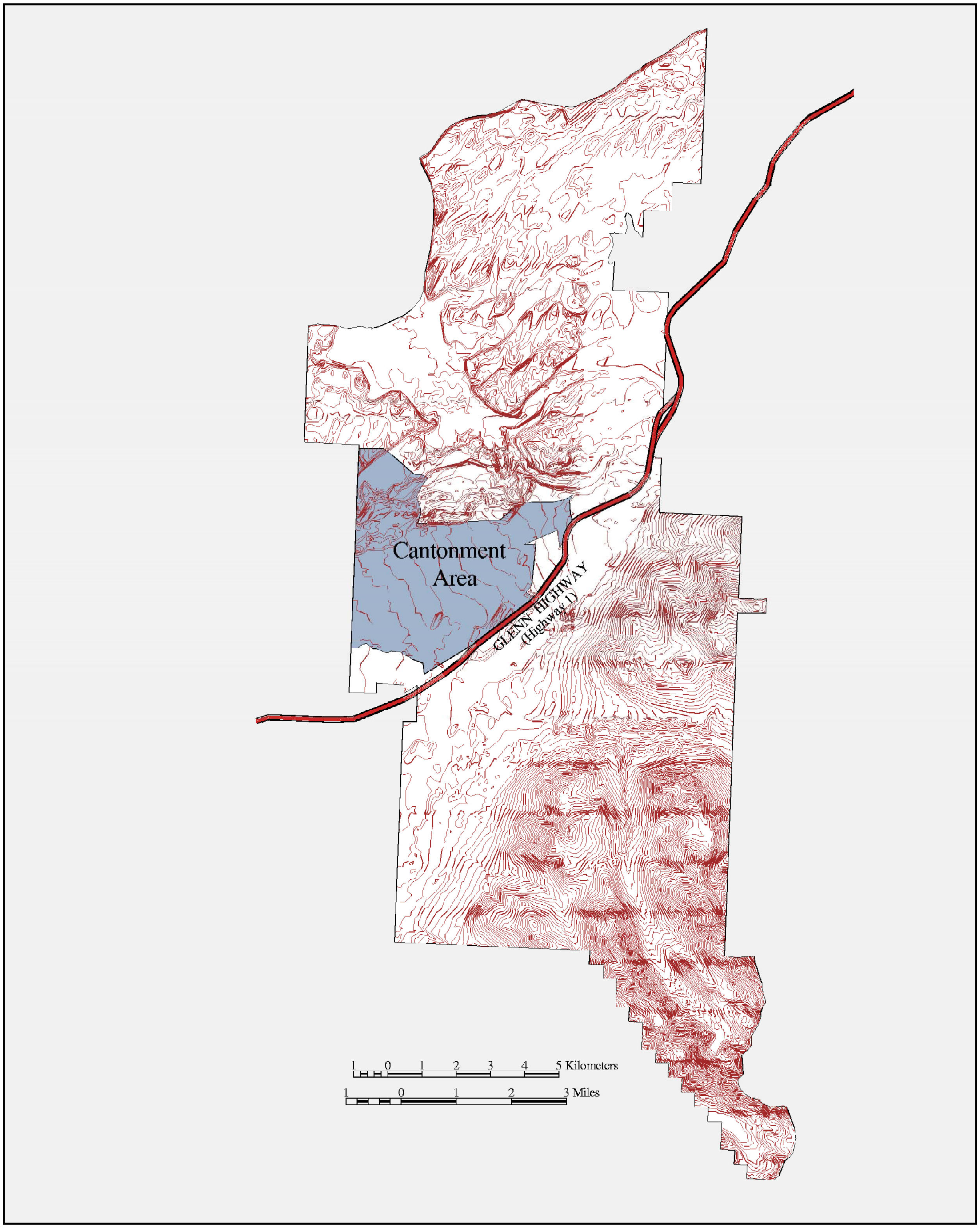


Figure 7-1. Topography of Fort Richardson.

tain front and thicken as they slope downward to Cook Inlet. Thickness varies from zero at the foot of the mountain range to 900 feet at Point Woronzof (CH2M Hill, 1994b). The upper part of the deposits is composed of gravel and sand ranging from 30 to 100 feet thick. Underlying the gravel is Bootlegger Cove Clay, a 60 to 200 foot layer of clay and silt with interbeds of sand. Below the clay is a 100 to 200 foot layer of sand and gravel that provides the major groundwater aquifer for the area (CH2M Hill, 1994b). Between the aquifer layer and the bedrock is a layer of poorly sorted glacial sediments (Gossweiler, 1984).

Bootlegger Cove clay is nearly impermeable and serves as a confining layer between upper and lower gravel layers. It inhibits downward flow of pollutants from groundwater in upper layers and results in an artesian aquifer in the lower gravel layer. Water from this aquifer flows into the Knik and Turnagain Arms at an estimated rate of 75 million gallons per day (CH2M Hill, 1994b).

The northern third of the Anchorage lowland consists of a complex of glacially deposited materials. These materials include morainal deposits of the Elmendorf Moraine, marking the margin of the former glacier occupying Knik Arm. Other glacial deposits consist of diamicton and other unsorted and poorly sorted till material and glacial alluvium, including glacial outwash gravel, kames, and kame terraces deposited at the edge of the former glacier (CH2M Hill, 1994b).

Fort Richardson straddles both the alluvial fan of the Anchorage plain and the moraine and glacial alluvium complex near the shore of Knik Arm. The gravel alluvium of the Anchorage plain underlies the main cantonment. Well-bedded and well-sorted gravel and sands provide good foundation conditions and plentiful construction material. The confined gravel aquifer is 200 feet to 400 feet below the surface in this area of the post (Selkregg, 1972). Groundwater flow in this confined aquifer is generally west to northwest (CH2M Hill, 1994b).

Just north of the cantonment area is the southern edge of the Elmendorf Moraine, a long series of ridges running east-west across Fort Richardson and Elmendorf AFB, roughly parallel to Knik Arm. Elevations of the moraine rise to more than 300 feet, especially in the west. The moraine is chiefly till, including diamicton and poorly sorted gravel. North of the Elmendorf Moraine is a complex of moraine and glacial alluvium deposits in the form of irregularly shaped hills (CH2M Hill, 1994b).

The complex of hills just south of ERF is part of this glacial alluvium deposit. Further north, on either side of ERF, are more moraine deposits. These deposits are more subdued in topography than the Elmendorf Moraine (CH2M Hill, 1994b).

7-3 Seismicity

Seismic activity in Alaska is greater than any other state in the Union. On Good Friday, March 27, 1964, southern Alaska experienced the strongest recorded earthquake in American history, estimated between 8.4 and 8.6 on the Richter scale. The quake's epicenter was approximately 80 miles east of Fort Richardson in Prince William Sound. Although the Anchorage area did not experience great loss of life, damage from the quake was considerable. Fissures in the Bootlegger Cove Clay led to land slides in business and residential areas of Anchorage that caused extensive property damage. Total damage to Fort Richardson was assessed at $17 million.

Fourth Avenue in shambles after 1964 earthquake.

The Fort Richardson area is seismically active and has experienced at least nine major earthquakes in the last 85 years. The area has also experienced tremors and ash fall from volcanic eruptions of Mount Spurr, Mount St. Augustine, and Mount Redoubt since 1954. Two faults, the Border Ranges Fault and the Bruin Bay-Castle Mountain Fault, border Anchorage. The Border Ranges Fault bisects Fort Richardson, running parallel to the base of the Chugach Mountains (Elmendorf AFB, 1994). Another fault, located in the Chugach Mountains, skirts the Ski Bowl area of the post.

7-4 Petroleum and Minerals

Leasing and permitting for petroleum and mineral extraction on Fort Richardson is handled by the BLM. Prior to issuance of a permit that allows these activities, the Army must concur and sign a statement of non-objection.

There has been no interest in oil and gas exploration on Fort Richardson because no oil-bearing basins are known to underlie the post. Potentially significant mineral and organic resources on the post include coal, gravel, sand, and peat. While coal is found on the post there have been no surveys to inventory the resource, nor is coal extraction likely to occur because there are vast known reserves north of Anchorage at Jonesville and on native-owned lands west of the village of Tyonek.

The most valuable and desirable mineral resource on Fort Richardson is gravel, that is used in highway, utility, and building construction projects. The Alaska Department of Transportation has repeatedly requested permission to extract gravel from Fort Richardson for construction on Glenn Highway and other nearby highway projects in Anchorage. As a result of these requests, 20 or more sites have been approved for gravel mining. Many of these sites are located along the Glenn Highway in the gravel-rich Elmendorf Moraine (see figure 7-4).

There are other gravel quarries (e.g., Otter Lake and Artillery Road) where gravel is extracted and used for Fort Richardson construction projects. One commonly used pit is near Bryant Army Airfield. Public service utility projects (e.g., electrical transmission lines, water mains, sewer, natural gas and petroleum pipelines) that pass through Fort Richardson use gravel obtained from the post for their projects.

Small sources of sand can be found on the post. Two areas have been developed for extraction, one in the Ammo Storage area and another adjacent to McVeigh marsh. Both have been closed due to impacts in sensitive areas. Peat is found in wetlands on the post, and it has been extracted from several areas for use in landscaping applications.

7-5 Soils

The relationship between vegetation and soil formation is inseparable. The history of soil development in the Fort Richardson area began when the Cordilleran Ice Sheet covered southcentral Alaska during the Wisconsin Glaciation from 100, 000 to about 15,000 years ago. Climates began to warm and ice sheets melted in the late Wisconsin Glacial Period due to changes in the Earth's orbit around the sun. Sediment cores from lakes on the Kenai Peninsula lowlands show that plant life returned to this area about 14,500 years ago (Elias, 1995). The earliest vegetation to become established was herbaceous tundra dominated by sedges, grasses, sage, and plants in the composite family. By 13,700 years ago, the herbaceous tundra gave way to shrub tundra dominated by dwarf birch and heath plants. Deciduous forest became established by 10,300 years ago. Dwarf birch gave way to a mixture of cottonwood, balsam popular, aspen, and willow. Conifer trees appeared in the Kenai lowlands about 8,000 years ago. These first conifers were thought to be white and black spruce. Although no pollen records have been collected and analyzed in the Anchorage area, including Fort Richardson, the development and progression of the vegetative communities after the ice sheets melted are thought to closely follow the patterns found on the Kenai. Recent glacial studies indicate that the ice sheets on Fort Richardson melted about 1,000 to 1,200 years after the ones on the Kenai (Hunter et al., 1997).

Soil development is determined by five primary factors: parent material, vegetation, topography, climate and time. Vegetation is a dominant factor of soil development and vegetative succession at Fort Richardson is thought to follow closely with the records obtained from Hidden Lake on the Kenai Peninsula with a time delay of about 1,000 to 1,400 years later. Therefore, the vegetation communities and soils on Fort Richardson would be about 1,000 years younger than the Kenai development. Boreal forests on Fort Richardson would have been expected to have evolved some 7,600 to 8,000 years ago.

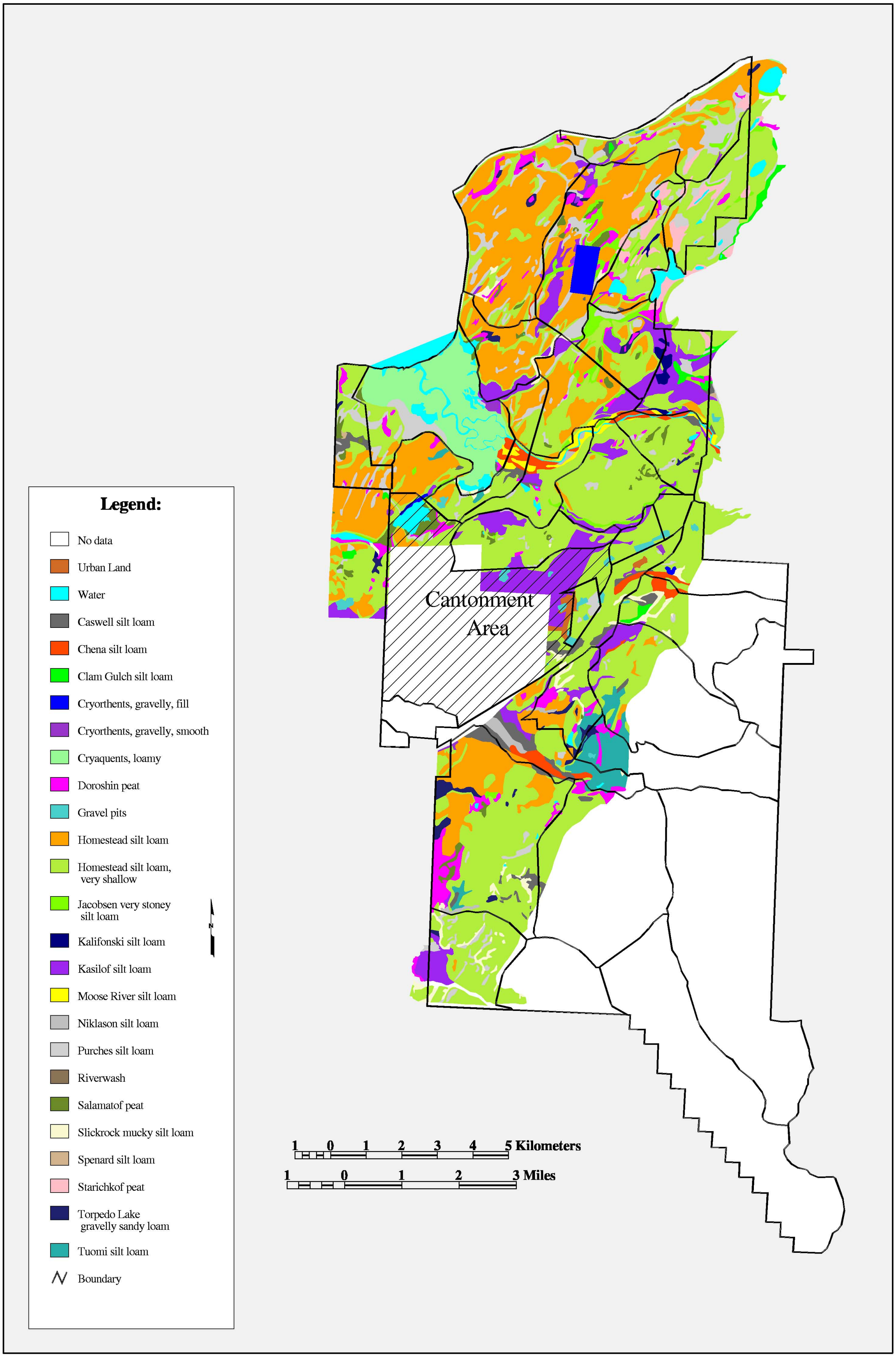


Figure 7-5. Soils Map Units from the 1996 soil survey for Fort Richardson.

Soil development on Fort Richardson from weathering of glacial deposits and the vegetative succession described above would be expected to be very slow. The present day description of soils bear out this expectation. The modern soils are immature and shallow. The thin A and B horizons are often irregular or broken. Coarse gravels and larger rock fragments from glacial till are omnipresent in all soil horizons.

The lowland area on Fort Richardson supports coniferous or mixed coniferous-hardwood forests. These forest soils are acidic and the lower part of the A horizon usually has a thin and often discontinuous layer of grayish-white or ash colored material. The ash colored layer is the result of highly leached A horizon and is typical of coniferous forest. These soils are typically called Podzols. For information on soil productivity see Section 9-3.

Appendix 7-5 contains descriptions of major soil series occurring on Fort Richardson. These are taken from the Soil Conservation Service (SCS, now known as the NRCS) study (SCS, 1979).

7-6 Water Resources

7-6a Surface Water

Fort Richardson's surface water resources are diverse and include numerous streams, lakes, ponds, and a saltwater tidal bay. Figure 7-6 indicates the location of surface water resources on the post.

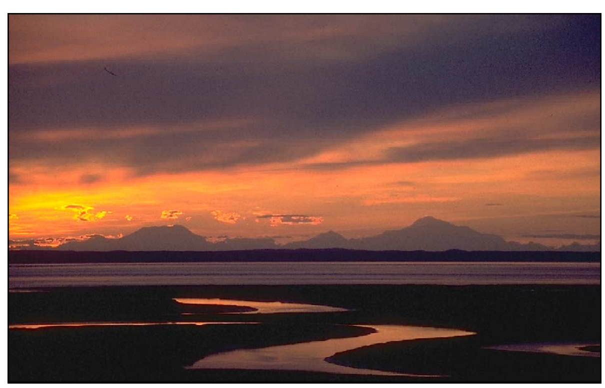
7-6a(1) Streams

Most streams on Fort Richardson flow from headwaters in the Chugach Mountains to the Cook Inlet (saltwater), and traverse the post in a westerly direction. Eagle River is fed by a glacier. Flow volume of streams fluctuates dramatically from season to season. During the long period of freeze, usually from October to April, flow is limited to groundwater seepage from aquifers into streams. Snowmelt typically begins in April and reaches its peak in June; stream flow is greatest during the months of June and July. After July most of the snow has melted, but the stream flow during the months of August and September remains steady because it is augmented by rainfall (Gossweiler, 1984).

Eagle River is the largest source of surface water on the post. It flows at an average rate of 519 cubic feet per second and drains approximately a 192 square mile watershed, characterized by both mountains and lowlands (CH2M Hill, 1994b). The Eagle Glacier comprises 13 percent of the watershed and snow and ice melting from the glacier is a major source of flow during the summer months (Gossweiler, 1984). River flow reaches its peak of more than 2,500 cubic feet per second during July and August. Periods of heavy rainfall or rapid melting from the glacier can generate water flow in excess of 3,600 cubic feet per second (CH2M Hill, 1994b).

Upstream of Fort Richardson, the Eagle River passes through the community of Eagle River. From there the river flows into the northwestern portion of the post and through the ERF tidal marsh before it empties into the Knik Arm of Cook Inlet (CH2M Hill, 1994b). In winter, the Eagle River is a clear stream with excellent water quality. During spring–summer, however, there are significant levels of suspended sediment from runoff and glacial melt (Gossweiler, 1984). Overall sediment loads, however, are fairly low in comparison with other glacially fed streams in Alaska (CH2M Hill, 1994b).

Besides the water that comes via the Eagle River, ERF is also fed by two small tributary streams, Otter Creek and Clunie Creek. Otter Creek is a perennial stream, which drains Otter Lake just north of the cantonment area, and then flows north into ERF. Clunie Creek, an intermittent stream, drains Clunie



Eagle River flows into Knik Arm with Mt. McKinley and Alaska Range as a backdrop.

Figure 7-6. Surface water on Fort Richardson.

Lake and other small ponds among the moraines on the northeast portion of the post as it flows west into ERF (CH2M Hill, 1994b).

On Fort Richardson, Ship Creek is second only to Eagle River in volume. It drains a watershed of 117 square miles, 90 of which are in the Chugach Mountains. From the mountains the creek flows west across a coastal plateau through Fort Richardson,

Upper Ship Creek flows through a pristine mountain valley.

Elmendorf AFB, and an industrial area of Anchorage before meeting Cook Inlet at the mouth of Knik Arm. Although there are no tributaries in these lowlands, the Anchorage area comprises 27 square miles of the creek's watershed.

Ship Creek traverses Fort Richardson from east to west for approximately eight miles. Entering the post, it initially flows through a three mile canyon of white water beginning at an elevation of 1,100 feet above sea level. Emerging from the canyon at an elevation of approximately 500 feet, it continues across the forested coastal plain to the western boundary of the post at an elevation of 230 feet. Ship Creek and its floodplain above the Glenn Highway is the least disturbed portion of the creek on Fort Richardson.

The Fort Richardson Dam on Ship Creek forms a sizable reservoir, which provides all the potable water for Fort Richardson and the Elmendorf AFB and nearly half the water for the Municipality of Anchorage. Fort Richardson and Anchorage have separate water treatment plants and delivery systems. Fort Richardson also has several backup water wells fed by a shallow aquifer along Ship Creek south of the post's Central Heat and Power Plant. Additional information regarding Ship Creek and Ship Creek Dam can be found in *Chronology of Water Use and Water Rights on Ship Creek* (Quirk, 1997).

Snowhawk Creek is a perennial tributary of Ship Creek flowing from its mountainous drainage basin. It drains a small cirque lake in the Chugach Mountains on the southern portion of the post and flows north through Snowhawk Valley into Ship Creek about six miles further downstream (Gossweiler, 1984).

Chester Creek and the North Fork of Campbell Creek are the only other perennial streams on the post. Chester Creek drains a small basin located on the southern portion of Fort Richardson on the western slope of the Chugach Mountains. It flows northwest until it leaves the post. Although it is a shallow creek, it usually has a constant flow of water (Gossweiler, 1984).

In the winter of 1996–1997, the main and North Fork channels of Chester Creek were damaged during construction of the Municipality of Anchorage's 48-inch water transmission line. The damage occurred in a wetland area the creek passes through, near the western boundary of Fort Richardson, and adjacent to the Muldoon Community in east Anchorage. The main channel was blocked with ice and the creek overflowed onto the property of nearby homeowners. The threat of flooding homes caused the contractor to drain excess water into the city's storm drain. In addition to the flooding problem, the stream was improperly reconstructed across the pipeline right-of-way.

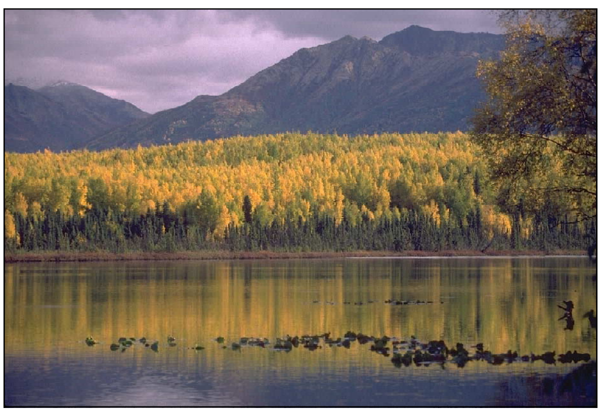
The ADF&G, the Alaska Department of Environmental Conservation, and the Alaska District, Corps of Engineers sent Notices of Violation (NOVs) to the Municipality of Anchorage Water and Wastewater Utility for violating existing stipulations for pipeline construction or for failing to obtain the required permits for the work performed. The improper alteration of Chester Creek was satisfactorily repaired in August 1997, and wetland vegetation plugs were transplanted adjacent to the creek. Other construction damage on the North Fork, where it crosses the pipeline right-of-way, resulted in the creek bottom being above grade causing alternating conditions of ponding and dewatering.

The North Fork of Campbell Creek drains a lake in the Chugach Mountains eight miles southeast of the post. It passes through Fort Richardson flowing northwest from the southern boundary to the western boundary. The creek is particularly scenic, and its water is quite clear. A waterfall is located in the southwest corner of the post (Gossweiler, 1984).

7-6a(2) Lakes and Ponds

Fort Richardson has 12 named lakes and ponds and several unnamed water bodies. The combined area for the named lakes and ponds is 348 acres. Five relatively large lakes, Clunie, Otter, Gwen, Thompson, and Waldon, are managed for recreational fishing.

Clunie Lake (116 acres) is the largest lake on the post. It is picturesque and situated in the northern, moraine area of Fort Richardson. It attains a maximum depth of approximately 33 feet and drains into Clunie Creek (Gossweiler, 1984).



Clunie Lake.

Otter Lake covers 93 acres and is the post's second largest lake. It receives the most fishing pressure. It is fed by a small creek on its southern end and drains into Otter Creek on its northern end. It attains depths of 23 feet (Gossweiler, 1984).

Gwen Lake is small and shallow with an area of 10 acres and a maximum depth of 11 feet. It is located two miles north of the cantonment area along a well-maintained road. Due to its small size and lack of depth, it cannot support fish over winter (Gossweiler, 1984).

Gwen Lake.

Thompson Lake is smaller but deeper than Gwen Lake. Its eight acres make it the smallest of the actively-managed lakes on Fort Richardson. It attains a depth of 21 feet and can support fish over winter (Gossweiler, 1984).

Waldon Lake is approximately 50 acres. It is only about eight feet deep, therefore it may not support fish during some winters. This lake is easily accessed.

The other seven lakes and ponds on the post are: Chain Pond, Web Pond, Lake Kiowa, Dishno Pond, Cochise Lake, Diablo Pond, and Snowhawk Lake. Snowhawk Lake is located in the southeastern corner of Fort Richardson and is the largest and least accessible of the seven. None of these other lakes or ponds support a fishery, except Dishno Pond which is stocked annually with catchable-sized rainbow trout for flyfishers. About 80 percent of Campbell Lake lies within Fort Richardson.

7-6a(3) Salt Water

Roughly 12 miles of shoreline along the Knik Arm of Cook Inlet form the northern border of Fort Richardson. Eagle Bay is located in the southern portion of this area, where Knik Arm merges with the Eagle River. Tidal activity in Eagle Bay has created an estuarine salt marsh encompassing ERF impact area. Numerous ponds dot the marsh. Many of these are shallow mudflat ponds, less than 6 inches deep that often dry up during summer. Others are more permanent and achieve depths of over 4 feet. These deeper ponds often are fed by freshwater streams and springs.

ERF is an estuarine salt marsh created by tidal activity.

In 1994, a comprehensive evaluation of ERF was conducted to address water quality of these ponds (CH2M Hill, 1994b). The salinity level varied from 1 to 46 parts per thousand (ppt). Salinity in most ponds was below 10 ppt. Tidal flooding of ERF infuses ponds with saltwater and sediments from Eagle Bay. Elevation determines frequency of floods, varying from mean sea level (msl) to 18 feet above msl. Flooding may occur daily during high tides in areas less than 12 feet above msl. In areas from 12 feet to 13 feet above msl, flooding occurs only with the highest tide each month, and in areas above 13 feet, flooding occurs only during extremely high tides (CH2M Hill, 1994).

7-6b Groundwater Resources

Two freshwater aquifers underlie most of Fort Richardson. These aquifers flow west from the Chugach Mountains to the Cook Inlet and are recharged by groundwater originating from precipitation in the mountains. The two aquifers lie in different soil strata, and are separated by a 60 to 200-foot layer of impermeable Bootlegger Cove Clay. The upper, unconfined aquifer lies in a 30 to 100-foot layer of well-bedded and well-sorted gravel near the surface. This aquifer usually can be accessed at depths of less than 50 feet (CH2M Hill, 1994b).

The lower, confined aquifer lies in a 100 to 200 foot-layer of sand and gravel. The impermeable clay above produces artesian conditions and protects the lower aquifer against seepage and pollutants from the surface, thus the water quality of this artesian aquifer is excellent. It is estimated that 75 million gallons of water originating from the mountains recharges the aquifer each day. This aquifer usually can be accessed from 200 feet to 400 feet below the surface. Wells drilled into the aquifer can produce up to 1,500 gallons of water per minute (CH2M Hill, 1994b).

7-7 Climate

By Alaskan standards, the Anchorage area has a moderate climate. Fort Richardson is in a transition zone between the northern continental climate of the Alaskan interior and the maritime climate of the Gulf of Alaska. The Alaska Range to the north and northwest of the post acts as a barrier to very cold air from the interior. The Kenai and Chugach Mountains to the south and east prevent the influx of maritime air from the Gulf of Alaska. The waters of the Cook Inlet and the Knik Arm serve to moderate temperatures and provide moisture (Elmendorf AFB, 1994).

Fort Richardson has a long winter with subfreezing temperatures that usually lasts from mid-October to mid-April (see table 7-7). High pressure weather

Fort Richardson's winters are long.

systems during this period may lead to successive days with temperatures below minus 35 degrees Fahrenheit (F). The spring is marked by the ice "break-up" starting in mid-April, and lasting until June, characterized by a rapid rise in temperature. Summer lasts from June to early September, and has a daily average temperature of 56 degrees F. Autumn on Fort Richardson is brief, lasting from about mid-September to mid-October.

According to a number of scientists, the effects of global warming are already taking a toll in Alaska. Damage to forests, loss of salmon habitat and widespread melting of permafrost are being attributed to a permanent and significant climate regime shift. Major changes in temperature, warming of rivers and extensive melting of permafrost have been clearly evidenced in both Alaska and Canada over the last 20 years.

Tree growth studies conducted by University of Alaska Professor, Glenn Juday, have found clear indication that normal cycles of forest growth changed dramatically starting in the early to mid 1970s. The studies also show that the forests have been experiencing stresses since then, often involving complex interactions of different effects of warming that have no precedent in the historical record. This could eventually lead to the boreal forest dying out and being replaced with grassland steppe vegetation that covered much of interior Alaska in the Pleistocene period ten thousand years ago. Melting of permafrost creates sinkholes and differential settling of the ground which damages roads, building foundations, airports, and other man-made structures. Significant amounts of salmon spawning habitat may be lost due to stream warming.

Although thermokarst (melting of permafrost) is not a major problem in most parts of southcentral Alaska due to only small isolated areas being underlain with permafrost, spruce bark beetle (*Dendroctonus rufipennis* [Kirby]) infestations have reached epidemic proportions during the 1990s. Warmer than average summers and other climatic conditions as well as large tracks of mature, even-aged, and unhealthy spruce forests have contributed to the beetle outbreak. Activity levels in southcentral Alaska have increased to nearly a million acres of active infestation (Dr. Edward Holsten, pers. com.). The damage is resulting in the catastrophic long-term loss of 60–80 percent of spruce trees larger than 9 inches in diameter. The infestations reduce forest diversity and increase fuel loading, which substantially increases forest fire danger in the affected areas.

Soils on Fort Richardson are subject to seasonal freezing. The average last date for a killing frost is May 15, and the average first date for a killing frost is September 8, providing a 115-day growing season (Elmendorf AFB, 1994). Average monthly temperatures for the Anchorage area are provided in table 7-7. Permafrost on Fort Richardson is all but absent, probably occurring only as remnants from the last Ice Age, deep within peat deposits.

Prevailing winds come from the west in summer and from the north and northeast in winter. Average wind velocity is six miles per hour (mph). Channeling of south and southeasterly winds passing over the Chugach Mountains, during low pressure systems called "chinooks", can lead to wind gusts up to 100 mph. These gusts can inflict significant property damage (Gossweiler, 1984).

Approximately 40 percent of the 15-inch annual precipitation falls from mid-July to mid-September (Gossweiler, 1984). The six months of winter account for another 40 percent of annual precipitation with an average of 72 inches of snowfall. Spring and autumn combine for a meager 3 inches of the annual precipitation (Elmendorf AFB, 1994).

Table 7-7. Average Temperatures (Degrees Fahrenheit) by Month, March 1941–December 1991 for the Fort Richardson Area (Elmendorf AFB, 1994).

Month	Average High	Average Low	Mean	Extremes Maximum	Extremes Minimum
January	19	5	12	49	-38
February	25	10	18	58	-33
March	32	15	24	51	-24
April	43	28	35	65	-20
May	54	39	47	80	12
June	62	47	55	86	33
July	65	51	58	83	35
August	63	49	57	82	29
September	55	42	49	74	20
October	41	29	35	63	-6
November	27	15	21	57	-20
December	19	7	13	53	-34
Annual	42	26	35		